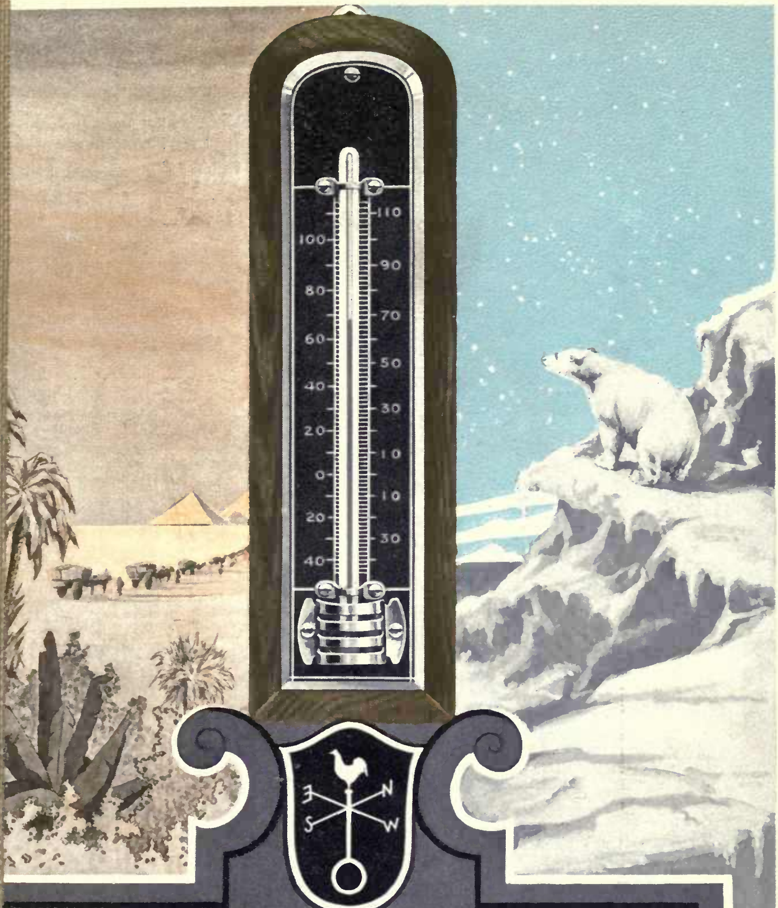

THE THERMOMETER AND ITS FAMILY TREE

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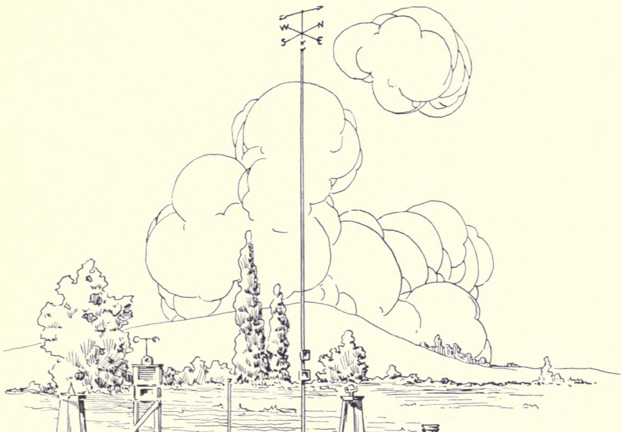
by

P. R. JAMESON, F. R. MET. SOC.



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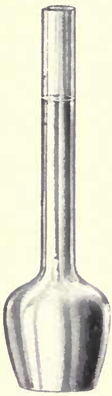
THE THERMOMETER AND ITS FAMILY TREE

IN looking at a thermometer—apparently a glass tube containing either quicksilver or a coloured liquid and placed upon a divided and figured plate of some description—one is not apt to realize the thought, skill and research it has taken to bring this simple, yet universally necessary article to its present status.



The Drebbel Thermometer About 1592

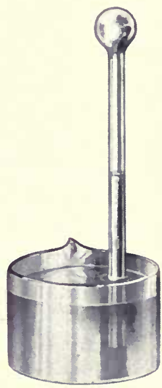
For many centuries scientists have worked in an endeavor to perfect it, but only during the past forty years have they found out all the details necessary to the manufacture of a more or less perfect article.

Many people are credited with its invention, Drebbel, a Hollander, being referred to more than any other, but to Galileo Galilei the laurels should be handed.

According to history it seems that about 1592 he invented at Padua an instrument described as "a glass containing air and water, to indicate changes and differences in temperature."

With the idea started, the Grand Duke of Tuscany investigated this "invention," and more or less perfected it between 1630 and 1640.

The original thermometer consisted of a glass tube about 16 inches in length with a hollow ball or bulb fitted at the end. The whole was heated until the air inside became rarified, when the open end was placed in water, the tube being kept upright.



The Sanctorius Thermometer About 1620

As the air in the tube cooled or contracted, the fluid (water was originally used) in the tube rose to a certain point and any subsequent changes caused the level of the fluid in the tube to be either elevated or depressed.

This was used by Sanctorius as a "heat measure" or fever thermometer. It is on record that he had his patients hold the top of the "thermometer" so the level of the fluid would be arrested at a point equal to the temperature of the person holding it. A "point" was undoubtedly determined by a normal, healthy person beforehand and it is reasonable to assume that Sanctorius drew his deductions by noting the distance above or below this "normally healthy" point.

M. Jean Roy, a French physician of note, made a thermometer similar to the one originally designed by Drebbel, but filled it with alcohol instead of water. He did not invert his "thermometer" but kept it in an upright position and noted the rise and fall of the spirit due to the expansion or contraction of it. This was about 1630.

Before ten years had passed, the Grand Duke of Tuscany had carried out his idea of first partly filling the tube with alcohol and closing the open end, thus sealing it and excluding the air.

Realizing that the level of the liquids in these various instruments meant nothing, pupils of Galileo sought to make a scale of temperature and melted on to the tube of their thermometers small glass balls about the size of a pin's head, the zero of the "scale" being the point to which the liquid fell in a freezing mixture of salt and water.

For the next hundred years or so the deepest confusion occurred, for not only had various types of instruments been invented, but no two of them agreed as regards their graduation. Many schemes and devices were used to determine satisfactory scales, but agreement could not be easily made.

In a book written in 1738 by Bernandinus Teleius great attention is given to this matter.

At one time, it seems the bright minds of Europe decided that the freezing point of liquors varied to such an extent that it could not be used as a test point, and suggested taking the temperature

> *"In a cave cut straight into the bottom of a cliff fronting the sea to the depth of 130 feet, with 80 feet of earth above it."*

Speaking of this, the author says:

> *"But with Dr. Hale's leave, this degree of temperature I do not think a very convenient term for universal construction of thermometers. Everybody cannot go to Mr. Boyle's grotto; and it is but few who can have an opportunity of making observations and adjusting thermometers in the cave of the 'Parisian Observatory.'"*

In speaking of the scale laid out by Sir Isaac Newton as having test points at freezing water, the heat of the human body, boiling water and melting tin, he says:

> *"I wish the world would have received this or any other determined scale for adjusting their thermometers, but I suppose they might be apprehensive of some inconvenience in this scheme."*

Robert Hooke and Hon. Robert Boyle, of the "Royal Society in London," were the first to realize the necessity of having a standard scale. About 1662, Hooke, placing his instrument in freezing distilled water, marked "zero" at the top of the column of spirit after immersion of the bulb. Soon after, he suggested that the second point should be the boiling point of water; but this does not seem to have been adopted at that time.

Delance suggested that the freezing point of water should be marked "cold" (-10°), the melting point of butter "hot" (+10°), and the space midway between "temperate" (0°), with ten divisions between each.

In 1714, Fahrenheit of Dantzig designed a scale for thermometers which showed the freezing of water at 32° and the boiling of water at 212°.

Many suggestions have been made as to why he graduated the freezing and boiling of water into 180 divisions, one being that as he was an astronomical instrument maker, and as his machines divided to full circles (360 divisions), he used a half circle for his scale.

Seventeen years later, Reaumur, a French physicist, designed a scale on which the freezing point of water appeared as 0 degrees, the scale between this and the boiling of water being divided into eighty equal parts.

Anders Celsius, Professor of Astronomy at the University of Upsala, proposed a scale in 1742, and called the freezing point of water 100° and the boiling point of water 0. These points were afterwards reversed by Christin of Lyons (France) in 1743, and the result is the well known Centigrade scale.

Athanasius Kircher was the first to use quicksilver in thermometers, although Delance once remarked "curious people use it," little dreaming that one day it would become universal in use.

In speaking of the faults of different liquids used in the early manufacture of these instruments Teleius remarks:

> *"We have, it seems, nothing left but quicksilver.*
>
> *"This is a very movable, and ticklish fluid; it both heats and cools faster than any liquor we know of or have had occasion to try."*

Quicksilver and alcohol have been accepted by the scientific world as a convenient and accurate means to indicate the temperature of anything with which the tube containing them may come in contact.

For high temperatures quicksilver is used, for it

FREEZES AT -38° Fahrenheit, -38° Centigrade
AND BOILS AT 674.6° Fahrenheit, -357° Centigrade

As the freezing point of mercury is fairly high, alcohol thermometers are invariably used in very cold climates, for this liquid

FREEZES AT -202.9° Fahrenheit, -130.5° Centigrade
AND BOILS AT 173.5° Fahrenheit, 78.5° Centigrade

From this it will be seen that quicksilver is unsuitable for any very low temperature and alcohol is unsuitable for any very high temperature.

THE CONVERSION OF THERMOMETER SCALES

Centigrade to Fahrenheit

To convert Centigrade degrees to degrees of Fahrenheit, multiply by 9, divide the product by 5 and add 32. When the temperature Centigrade is below 0 Cent. deduct 32 instead of adding.

Fahrenheit to Centigrade

To convert Fahrenheit degrees to degrees of Centigrade, subtract 32, multiply by 5 and divide by 9. When the temperature Fahrenheit is below 0 Faht. add 32 instead of subtracting.

Reaumur to Fahrenheit

To convert Reaumur degrees to degrees of Fahrenheit, multiply by 9, divide by 4 and add 32. When the temperature Reaumur is below 0 Reau. deduct 32 instead of adding.

Reaumur to Centigrade

To convert Reaumur degrees to degrees of Centigrade, multiply by 5 and divide by 4.

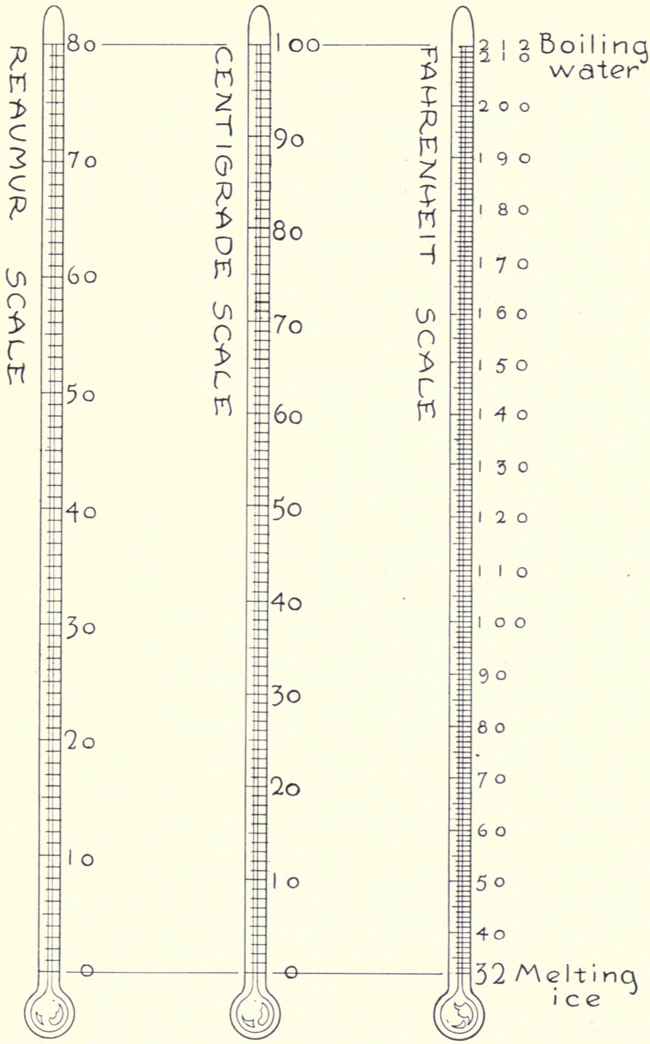
Centigrade to Reaumur

To convert Centigrade degrees to degrees of Reaumur, multiply by 4 and divide by 5.

Cent. Water Freezes at 0°
" Boils " 100°

Faht. Water Freezes at 32°
" Boils " 212°

Reaumur Water Freezes at 0°
" Boils " 80°



The Three Standard Scales for Thermometers

THE MAKING OF GLASS THERMOMETER TUBING

As the value of a thermometer depends to a great extent on the grade of glass and the care taken in making and drawing it into the tubes, a few words regarding it will be of help to the reader and will give an idea of how the small "hole" or "bore" up which the quicksilver travels, is formed in the glass.

Glass is hard, brittle and transparent. It is formed by fusing together mixtures of silicates of potash, soda, lime, magnesia, alumina and lead in various proportions, according to the quality or kind of glass required.

The first step in the manufacture of glass tubing is to take an iron pipe, about five feet long and collect on about two inches of the end of it (by dipping it in molten glass) a quantity of glass about as large as a quart milk jug. When this glass is still in a plastic state (i. e., not hard) a bubble is formed in the centre of it by blowing hard into the end of the iron pipe. The glass is then rolled over a plate so it becomes cylindrical in shape (like the tubular record of a phonograph) but solid, except for the hole in the centre caused by blowing through the iron pipe. This rolling process causes the roughly blown round hole in the glass to attain a cylindrical shape—more or less perfect in appearance.

Rolling the Glass Mass

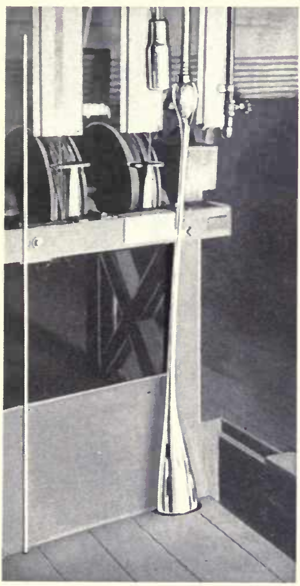
The next process is to flatten the glass, which is accomplished by applying pressure to the top and bottom of the mass. This operation causes the cylindrical hole in the centre to flatten out a trifle, due to pressure, and to appear in the shape of a thick ribbon instead of a circular hole.

White enamel glass is then put on that part of the tube which is directly behind the "hole" or, as it is called in the finished thermometer, the "bore."

The mass is now put into hot glass so it is absolutely covered with a new coat of it. During all these processes the glass develops "waviness" and to get it into proper condition and solidity it has to be rolled on iron slabs. The outside is chilled somewhat, so the inside retains its correct shape.

In order to properly read the quicksilver in the column, a great many tubes have "lens" fronts. This lens is formed on the glass by putting it in a "V" shaped mould with the white enamel glass uppermost. The mass then represents a wedge with a rounded top.

Now remember what has been done to this glass to make tubing from it. A hole has been blown in the centre of the original "lump" of glass; it has been rolled out, flattened on the top and on the bottom, it has had white enamel put upon the back, and has been covered with a second coating of glass. Finally it has been rolled again to take imperfections out and then the lens has been formed on the front.



Drawing Plastic Glass Into Tubes

At this point it looks like a piece of glass tubing about 5 inches thick and 9 inches long, on the end of an iron tube with a long bubble in the centre, some white glass behind the bubble and the glass formed in a "V" or wedge in front of the bubble.

Now the delicate operation comes of "pulling this glass out"—or "stretching" it into the small thin canes of tubing such as are used in thermometer making.

The mass of glass is put on a hot iron plate—six or eight inches in diameter, with the iron tube through which the hole was blown pointing upwards. This tube is secured to a wire cable extending upwards for about 150 feet, which is attached to a motor.

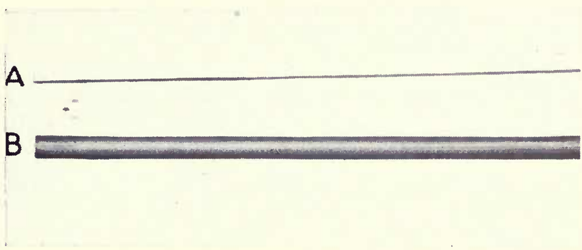
The glass is now ready and the motor is put in operation,

with the result that the plastic glass is pulled upwards for about 150 feet into a more or less perfect tube.

The hole which was originally blown in the centre becomes the minute hole up and down which the quicksilver travels;—the white enamel glass becomes the white back of the thermometer tube, and the "V" front becomes the magnifying lens.

The tubing is now ready for cutting up into "canes," or lengths of glass, to be used for tube making. The ends of the length after drawing are useless, due to distortion in forming them.

Great care has to be taken in sorting this glass, for the size of the hole or "bore" in the centre of the glass varies, and as a consequence quicksilver or spirit will rise slowly up a tube having a large bore, and quickly up a tube having a small bore, if the bulb or quicksilver ends of the thermometer are of the same size.



A Thermometer Bore
B Human Hair

In some thermometers the "bore" is very much finer than the diameter of a human hair, and the relation of the capacity of the bulb which holds the quicksilver to the tube up and down which it travels, is roughly 1000 to 1.

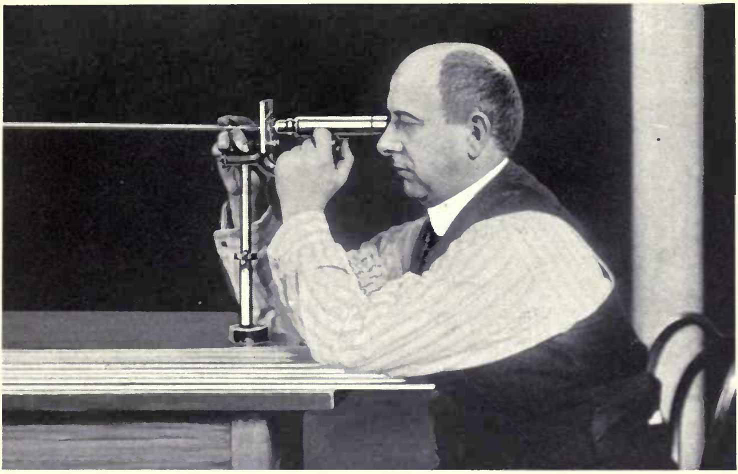
The "grading" of these tubes calls for the work of an expert, for it can only be done by putting the end of the glass to a powerful microscope and measuring the "bore" by means of hair lines under magnification.

This practically completes the making of glass tubing.

THE MAKING OF THE THERMOMETER TUBE

The lengths of glass tube, or "canes" as they are called, are now cut into pieces twice the size of the thermometer into which they will ultimately be turned.

The sharp flame of a blow pipe is made to play in the centre of the tube. When it has become warm enough it can be pulled apart, making two complete tubes, each of the same size and each sealed at one end.



Measuring the Bore of a Tube

One of these tubes is now taken and an ordinary rubber bulb is fitted to the OPEN end.

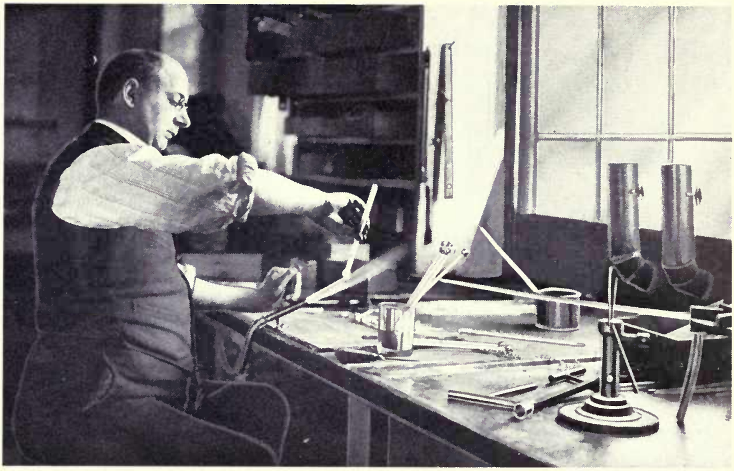
The CLOSED end is now heated, pressed and manipulated until the glass is more or less solid at this end. If the rubber bulb is now pressed, air is forced down the tube and when it reaches the molten end a bubble is formed. This bubble is called the bulb. (See illustration page 13).

In the manufacture of thermometers of anything above good grade, special hard glass is melted on to the end of the tube, so that the bulb is formed from this glass instead of from the tube glass.

Sometimes these bubbles or bulbs are made large and sometimes small—it all depends on what is required of the finished thermometer. If the bore in the tube is large and the bulb large, or if the bore in the tube is small and the bulb is small, the quicksilver will rise much more slowly in the tube than if the bore is small and the bulb large.

Every tube, therefore, having a certain bore must have a certain sized bulb to make it work in a particular manner. If it were required to create a thermometer in the Fahrenheit scale with the "freezing" at a certain point—say $\frac{1}{4}''$ from the bulb, and a 120° point, say $\frac{1}{4}''$ from the top of the tube, the bore of the tube would have to be measured and the bulb would have to be of a certain exact size.

It is possible with a microscope to measure the bore accurately and it is possible to determine the size the bulb should



Filling a Tube With Quicksilver

be, but it is impossible to make it work so that at certain temperatures the quicksilver would stand at a number of predetermined points on the tube.

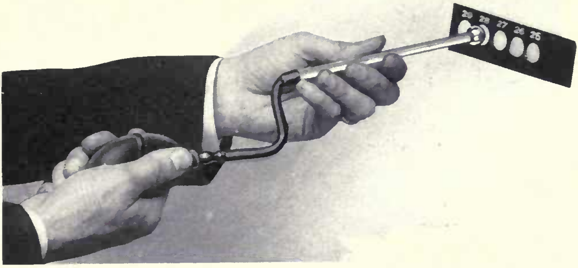
Plates having different sized holes in them are supplied to the tubemakers and with the workman's knowledge of the size of the bore, the approximate size of the bulb can be determined when they know the lowest point and the highest point the thermometer will be required to register. For instance, a bulb $\frac{1}{4}''$ in diameter might, if fitted to a tube having a certain bore, have a range of scale showing 200° from its highest point to its lowest point. If the bulb was made $\frac{1}{2}''$ in diameter, the range of scale might be equal to 50°.

After the bulb has been formed to the correct size, and while it is still hot, the open end of the tube is placed in a jar of pure, clean quicksilver. As the glass cools, the air in the bulb and tube contracts, drawing the quicksilver up into it.

This process will only partially fill the tube and in order to complete it, the tube after cooling is taken out of the jar, and with the bulb downwards more heat is applied, when it is again inverted in the jar and so on, until the bulb and tube are completely filled.

A process known as "roasting" is carried on, to expel every particle of moisture.

In order to properly seal and close the tube, a gas flame is blown across the top of it until the glass becomes very plastic.



BLOWING AND GAUGING THE BULB

The top of the tube is now drawn away in exactly the same way as it is drawn in the original manufacture—very thin—but still having a very minute hole or bore in the centre.

Heating the bulb again drives the quicksilver to the top of the tube once more and it travels along the newly made thin tube, expelling all the air. If the glass at the extreme top of the main tube, or at that portion of it which starts to thin out by the last operation, be melted, it will seal this hole and, providing the operation is accomplished carefully, will prevent any air from entering the thermometer, and the quicksilver will flow back to the bulb of the tube as it cools.

This end, or hook as it is called, is used to securely fasten the thermometer tube to its scale.

The thermometer tube is now complete, for a bulb has been formed at the end, the tube and bulb have been filled with quicksilver, the air expelled and the end sealed. The quicksilver is now free to move up and down the tube as soon as temperature changes either expand or contract it. When the surrounding air gets warmer the quicksilver expands and rises in the tube and when the surrounding air gets cooler it contracts and falls.

Although we have our tube, bulb and quicksilver made satisfactorily, we have not a thermometer, because the height of the quicksilver in the tube for any temperature has not yet been determined.

To properly accomplish this it is necessary to have water in receptacles of different temperatures, one at 32° Faht., one at 62° Faht., and another at 92° Faht., if the thermometer is to be used for ordinary living or room temperature.

The 32° Faht. point is obtained by crushing ice, as 32° Faht. is the temperature of either freezing water or melting ice. A point 2° Faht. is obtained on some thermometers, being reached by a brine solution.

In each of these "baths" a thermometer of known accuracy is placed and left immersed a sufficient time to enable the quicksilver to come to rest, thus determining the correct temperature of the water, which must be constantly agitated, in order to keep it from becoming cooler on the sides than in the centre, or vice versa.

Water in thermometer manufacturing is mechanically controlled at the necessary temperatures, but if by chance it should rise or fall below the desired point, it can be readily adjusted by introducing either cold water or steam, dependent on the condition of it.

If the bath is controlled and has a temperature of 62° Faht., the thermometer tube which has to be tested is put in and, when the quicksilver has come to rest, a line is put upon the tube at the level of the quicksilver, thus indicating the point at which the quicksilver stands when the temperature is at 62° Faht. This operation is repeated in a bath of 92° Faht., and also in crushed ice at 32° Faht. A point 2° above zero Fahrenheit is reached in cold brine.

Four marks, divisions, or "points" as they are called, have now been determined and if they are equidistant it is reasonable to assume that each can be sub-divided into thirty equal divisions, i. e., from 2 to 32, from 32 to 62, and from 62 to 92. The divisions can be extended below 2 and above 92 at the same ratio with reasonable accuracy.

A brass plate is now taken, which when completed will form the scale or face of the thermometer, for upon it the graduations have to be placed,—also the figures.

The thermometer tube is set upon this plate and the marks which denote 2°, 32°, 62°, and 92° Faht., are reproduced in exactly the same positions upon it. A dividing machine is arranged to cut or engrave the necessary divisions. It can be finished in any desired style and the thermometer tube permanently placed upon it. Great care must be exercised in seeing that the points on the tube agree exactly with the same points on the scale.

This practically completes a common type of thermometer. Refinements in manufacture are many and there are various and obvious reasons why a thermometer apparently looking the same as another should cost two, three or even four times as much.

ERRORS WHICH MUST BE GUARDED AGAINST

MANUFACTURING

(A) Careless "pointing" of the tube will, of course, result in erroneous readings and it is one of the most common sources of trouble in practical thermometry.

This can be caused through inefficient labour, through carelessness in placing the points upon the tube, or in letting the test baths get either too cool or too warm, during the pointing process.

Occasionally the thermometer tube will slide from its position on the scale and naturally all indications will be reading either above or below the true reading.

(B) If the bore of the tube is erratic, the quicksilver will naturally rise more slowly in parts which are larger, and faster in parts which are smaller.

The theory of this was pointed out on page 11, which explained the connection between the bulb and the bore. The smaller the bore the quicker the rise of the quicksilver in the tube.

(C) Impurities in the quicksilver make the bore of the tube rough and if the quicksilver is dusty, particles of it will stick to the bore of the tube, and besides being unsightly it will cause the quicksilver to appear sluggish in its action.

(D) As glass shrinks after manufacture, it is necessary in order to have a thermometer keep its readings correct, to make sure the glass is properly "seasoned."

The shrinkage of glass is imperceptible, but it is easy to realize that if the bulb and bore of the tube contract the smallest amount, the quicksilver will be driven higher in the tube, so that a point, say 40° Faht., might be correct on the scale made for the tube when new, but after the tube had contracted, or shrunk, or become seasoned, might read 46° Faht., or even 48° Faht., depending on the quality of the glass. The only way to overcome this is to keep tubes in storage for eighteen or even twenty-four months before determining the "points," so that all contraction of the glass will have passed and the indications will be permanently accurate.

BLUNDERS WHICH CAN BE AVOIDED

OBSERVING

(A) Nothing is so disheartening to an observer of temperature, whether he be noting temperature of a room, the soil, the outside air, or whatnot, as readings which he feels he cannot rely on.

Naturally it is essential in the first place that the thermometer being used is of known accuracy and will remain so. A little extra cost in the original purchase of a thermometer will never be regretted.

(B) All thermometers are affected by the surrounding air. When observing the readings be careful not to stand so near the bulb that it will be affected by the warmth of your body or breath. This is a continual source of trouble, especially if the thermometer be a very sensitive one.

(C) Take great care in noting the proper division on the scale. Some thermometers have their divisions in 2° lines, some in 1° lines, some in $\frac{1}{2}$° lines and some in 1-5°, 1-10°, etc. Errors are often made in reading 2° lines as 1° lines.

(D) In reading be sure and get the eye level with the quicksilver. If you read it from below the reading will appear too high, and if from above too low.

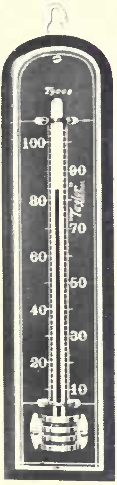
(E) In moving a thermometer into a fresh place remember it takes some time for it to adjust itself to the new temperature. This, of course, depends on the sensitiveness of the instrument. Fanning it, or passing it carefully through the air for some time will greatly help it.

(F) Beware of the word "Standard!" It is a most abused term! The word is placed on some thermometers that are not standard in any sense of the word. In experience the writer has found thermometers marked this way with errors varying from 3° to 10° Faht.

(G) Do not condemn a thermometer because it does not agree with one hung near it. Remember these instruments indicate the temperature of the air which surrounds THEM and NOT the temperature of the air one inch or twelve inches away.

TYPES OF THERMOMETERS

The style of thermometer ordinarily used for the purpose of determining the temperature of rooms, offices, corridors, etc., is that having a metal plate with the thermometer tube set upon it, the whole being fitted to a wooden back, of varied styles and descriptions.



Room Thermometer

Such a thermometer is very satisfactory, providing it is not influenced by direct sunshine, draughts, open windows, radiators, air furnaces, etc. Care should be taken when fitting it on the wall to see that no chimneys or air shafts pass through that part of the wall, causing it to be excessively hot or cold. When convenient a thermometer should be set two or three inches away from a wall, so that it may get correct circulation of air around it.

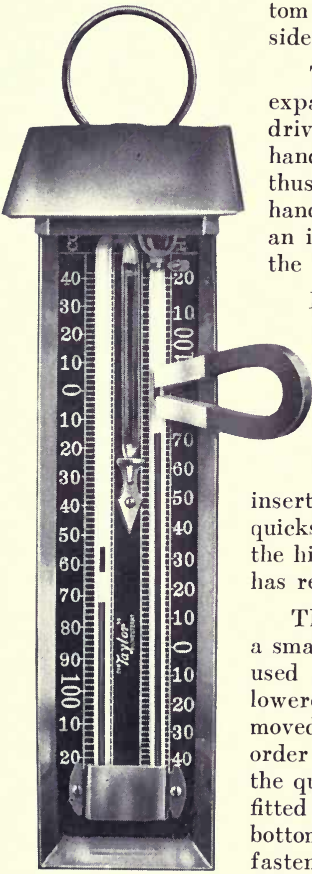
The most satisfactory height for a room thermometer is about 60 inches to 70 inches above the floor. Thermometers having coloured alcohol in them in place of quicksilver can be much more quickly read, but they are somewhat sluggish in their working, compared to those in which quicksilver is used.

Sometimes the alcohol may become separated from the main column, but it can be easily joined to it by swinging the thermometer sharply backwards and forwards with a pendulous motion, taking care that the bulb is downwards. It is also desirable to occasionally examine the upper part of the tube and to see that it is perfectly free from detached portions of alcohol. An easy method of correcting this is to take the thermometer with the bulb in the right hand and strike the top against the palm of the left hand. The alcohol at the top of the tube will slowly start to run down towards the main column. When detached portions are joined, the thermometer should be allowed to stand in an upright position for about half an hour.

This simple form of thermometer gives indications of existing temperatures. In sick rooms, greenhouses and many other places, it is interesting and sometimes necessary to have a knowledge of what the temperature has been. For this purpose a thermometer capable of giving maximum and minimum temperatures is used. The one most common, interesting, and effective is a pattern designed by Mr. James Sixe, of Canterbury, England. It consists of a glass "U" shaped tube with the ends terminating sometimes in round balls and sometimes in a ball at one end and a glass cylinder at the other. The latter pattern is in all ways

preferable. The tube is completely filled with creosote to within almost one-half inch of its top, which is filled with air. Prior to this quicksilver has been put into the lower portion of the "U," but NOT for the working member, as popularly supposed.

If the illustration be examined it will be found that the left side scale is figured from 120° at the bottom to 40° at the top, while the right hand side is practically the reverse of this.



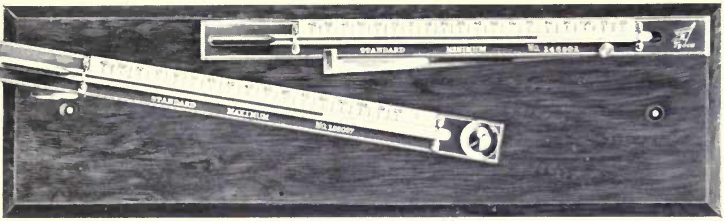
High and Low Thermometer "Sixe's Type"

The creosote in the tube in the centre expands when the temperature increases, driving the quicksilver down on the left hand side and up on the right hand side, thus increasing the air pressure in the right hand bulb. As the right hand side shows an increase in its scale reading it is called the "Heat or Maximum" side of the tube.

If the temperature lessens, the creosote will contract so that the quicksilver will fall on the "Heat" side and rise on the "Cold" or "Minimum" side, which shows the thermometer scale decreasing.

Indices are carefully made and inserted in the tubes above the levels of the quicksilver, so they can be used to indicate the highest and lowest point the thermometer has reached since its last setting.

The index is a miniature glass bottle with a small piece of steel wire inside it. Steel is used so that the index can be raised or lowered by means of a magnet, which can be moved up and down in front of the tube. In order to keep the index from receding with the quicksilver, two hair-like appendages are fitted to it (one of these is fastened to the bottom and points upwards, the other is fastened to the top and points downwards). As the quicksilver rises on either the "Heat" or "Cold" side, the index is raised on the surface of it, and when the quicksilver recedes the index remains stationary until reset with a magnet. It will then indicate the highest and lowest reading since its last setting. Another type of thermometer to give maximum and minimum temperatures is shown on page 19.



High and Low Thermometers. Horizontal Type

This consists of two separate thermometers set horizontally, one to give maximum readings and the other minimum. The maximum instrument is quicksilver-filled, the tube being arranged in such a manner that when the temperature cools the quicksilver cannot, by itself, set back into the bulb. This allows it to remain indefinitely in the tube. In order to reset it, it is necessary to swing it sharply a couple of times, when the quicksilver will easily and quickly be driven back into its bulb.

The minimum thermometer is alcohol-filled and has a small index set in the fluid. By holding the thermometer upside down this index will flow down the alcohol to the end. It should now be placed horizontally. When the air cools the alcohol is naturally drawn toward the bulb, bringing the index with it. When it rises again the index is left stationary in the tube, indicating the lowest, or minimum, temperature. To reset it, invert the thermometer, when the index will flow again to the end of the alcohol column.

As they are of approved standard type, the thermometer tubes have the temperature divisions etched upon them. This is duplicated every 5° or 10° on the scale itself.

Any thermometer marked "Standard" and not having its scale divided and etched directly on the tube itself, is not a standard thermometer. Standard thermometers are always accompanied with a certificate of correction which shows the error (if any), so that true readings of temperature can be arrived at.

Thermometers with glass scales are made for exposure outside of windows, so that outside temperatures can be read from inside.

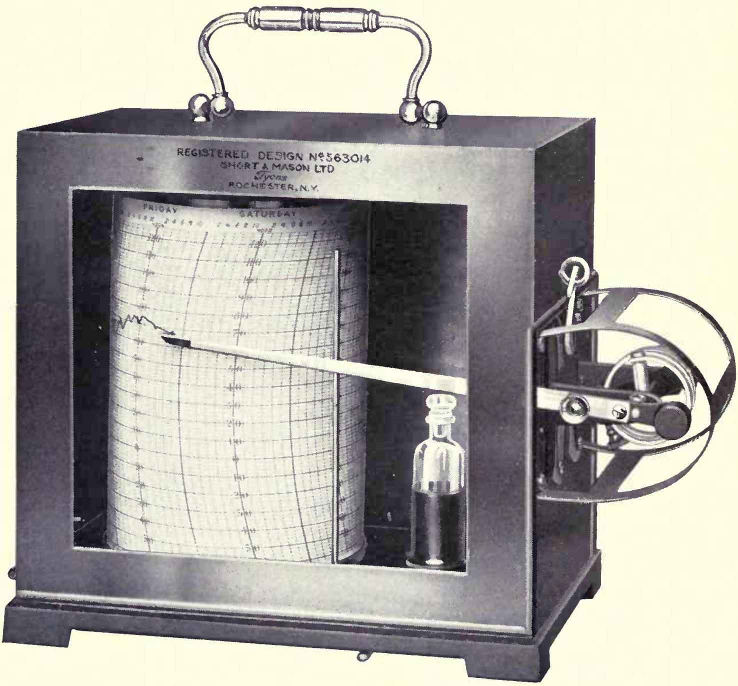
The figures on the scale are either etched permanently upon the glass or are painted upon it and baked in, so that water, snow, sunshine, etc., will neither fade nor wash them out.

Such thermometers are usually fitted outside the window, the metal arms allowing them to be held far enough away to prevent the warmth (in winter) from the window affecting them.

A northern exposure is the best if it can be found, for the sun will not then upset the readings of the instrument, as will be the case if it be exposed on the south, where the sun will, when out, always shine upon it.

In some instances it is necessary to have knowledge of what the temperature has been during any previous period, or for any particular time. An instrument known as a "thermograph" or recording thermometer, is used for this purpose.

Instead of using a quicksilver or alcohol thermometer the working part consists of a spiral metallic coil, which is very sensitive to changes of temperature. To this coil is fitted an arm, about seven inches long, to the end of which is fitted a pen which



Recording Thermometer

registers on a drum (containing a clock) the different changes as they take place.

The clock rotates upon its axis once a week and has wrapped round it a chart on which are divided the days of the week, each day being divided into two-hour spaces.

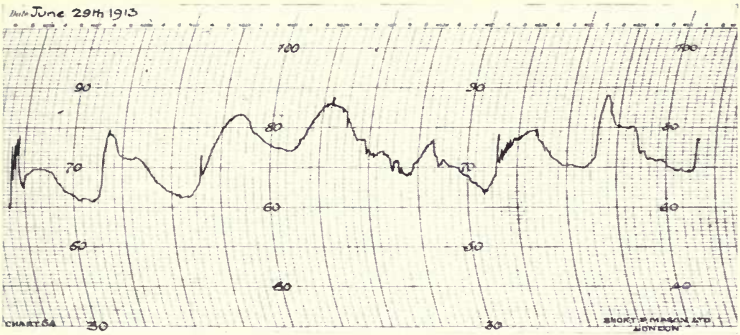


CHART OF RECORDING THERMOMETER

The pen on the arm rises and falls as the temperature increases or decreases and as the clock revolves a tracing is made on the chart, which also indicates the time at which such changes occur.

In a greenhouse, sick room, or anywhere where temperature is of consequence, the information one gains by consulting the ordinary thermometer is not sufficient, for in the case of the greenhouse, the thermometer early in the morning may show 45° Faht., but who is to know the extent of its fluctuations throughout the night or if it went to or below the freezing point, killing all the young growth which was being so carefully guarded?

The same applies to the sick room. It can be easily seen if the temperature of the room is being maintained, or if it is fluctuating materially.

Records can be filed and kept for reference, for one never knows when such information may be needed.

There is one type of thermometer which can be found in the most remote parts of the earth—in the frozen Arctic and in the sweltering tropics,—men never travel without it. It is used among the uncivilized as well as the civilized, by all races of mankind, irrespective of colour or religion. It is called the "fever" thermometer.

It is a well known fact that during health the same degree of temperature is virtually maintained. No matter whether it be winter or summer our bodies contain the same amount of heat if they be in a normal, healthy condition.

They not only contain it, but do so with a beautiful and natural exactness.

The temperature of a human being is not the same in all parts of the body, so, to establish a common standard, the medical fraternity accepted the temperature as taken under the tongue.

In some cases (such as in young children and those suffering from delirium), this is not a practicable place, so the rectum, or a point under the arm is selected, although the latter is not a very satisfactory point of contact, on account of the time the instrument takes to register the maximum temperature.

From a vast number of observations, a point 98.6° on the Fahrenheit scale has been determined as "Normal health." If the thermometer should rise or fall, or fluctuate from this point, the delicate mechanism of the body is in some way deranged. Some people are "subnormal" and others are "abnormal," meaning that their individual and correct temperature is a fraction of a degree below or above the 98.6° Fahrenheit.

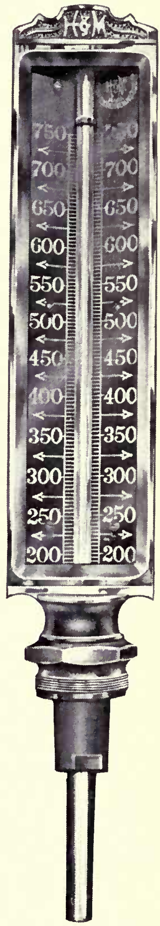
The "average," as are all averages, was probably determined from a good many thousand readings.

Fever thermometers are made to register the maximum temperature by leaving the quicksilver end under the tongue for 2 minutes, 1 minute, or $\frac{1}{2}$ minute. The tube is made in such a manner that while the quicksilver will rise in the tube as the temperature increases, it will not "set back" to the bulb after it is taken from the mouth and becomes exposed to a lower temperature. This is called a "self-registering" feature and it is necessary after each observation to hold the thermometer firmly by the upper end with the bulb downward and swing or shake it in such a manner as to force the quicksilver back toward the bulb.

The instrument should be carefully cleansed after each reading, to prevent the spread of any infection, and should be kept in as sanitary a case as possible.

Since a fever thermometer must be and must remain of absolute standard accuracy, it is easy to see that good ones cannot be cheap in price and that they cannot be purchased for a "mere trifle."

If the glass is not properly "seasoned," if the "points" are not most carefully determined



Industrial type of thermometer to 750° Faht. for determining temperature of superheated steam.

and if the scale is not accurately divided, the instrument is more than useless.

An accurate fever thermometer is of untold value in a house, hospital, travelling kit, or whatnot, but an inaccurate one is a positive danger to the owner.

Thermometers for specific purposes have to be manufactured in a certain manner, both as regards their style and adjustment. A thermometer is always a thermometer, but it is impossible to make a single thermometer to cover a multitude of purposes. For instance, a thermometer used to indicate room temperatures is quite impracticable as a thermometer for indicating the temperature of the various mixtures used in candy making.

Thermometers are used in the manufacture of asphalt, candy, coal, oil, wood drying, tobacco, milk, artificial teeth, dough, ham, ice cream, maple and ordinary sugar, and are used in connection with babies' food, the bath, brewing, incubating, cold storage, fruit evaporating, hop curing, milk testing, photography, the soil, hot water heating, milk pasteurizing and sterilizing, orchards, railway coaches, refrigeration, veterinary work, vulcanizing, and a thousand and one other purposes, each one being of special design and especially adapted for its individual use.

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